TF 2103

Wide Range Oscillator

MAINTENANCE AND FAULT FINDING MANUAL

MARCONI INSTRUMENTS LIMITED

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WIDE RANGE OSCILLATOR
TF 2103

MARCONI INSTRUMENTS LIMITED
ST. ALBANS HERTFORDSHIRE ENGLAND

TF 2103 Wide Range Oscillator

Maintenance and Fault Finding Manual

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Illustrations:

Circuit Diagram of Wide Range Oscillator Type TF 2103 (with waveforms) ---------- Fig. 1

Chart of Classified Faults ---------- Fig. 2

Component Layout on Printed Circuit Board ---------- Fig. 3

Copper Connections " " " " " ---------- Fig. 4

TF 2103 Wide Range Oscillator

Maintenance and Fault Finding Manual

1. Introduction

The specification and operating instructions for the TF 2103 are presented in the Marconi publication entitled 'Transistorized Wide Range Oscillator type TF 2103 Instruction Manual', a copy of which is provided with the instrument.

The publication covers the re-alignment of certain of the oscillator's parameters. In the following manual, however, instructions are given for the complete re-alignment of the instrument, fault locating charts and signal waveforms are included to facilitate instrument servicing.

2. Basic Circuit Arrangements

The TF 2103 employs a transistor Wien-bridge variable frequency oscillator as the signal source; this is followed by an inverter/amplifier when sinewave output is selected, or by a Schmitt trigger circuit when squarewave output is selected.

The signals of selected waveform and frequency are applied to a complementary emitter follower output stage and then pass via an attenuator to the output terminals. Amplitude stabilization is provided by thermistor-controlled negative feedback.

3. Alignment Procedure

(a) Remove the unit from its case.

(b) Switch supply ON by turning the attenuator switch.

(c) Check the output voltage of the batteries or mains power unit: this should not be less than 17V for the purpose of alignment and for general operation the supply should not be less than 12V.

The output ripple voltage of the TM 9808 power supply should not exceed 1mV.

(d) Using a small screwdriver set potentiometers RV1 and RV6 to approximately their mid-track positions. (See diagram S63/34, Fig. 3 for location of components).

(e) Select 'Sinewave', and ensure that all frequency range push-buttons are 'out'.

(f) Set the attenuator switch to '1V' and the variable amplitude control to '2.5'.

In order that the frequency calibration shall conform to the specified accuracy of ± 3%, it is required that two 0.15μF ± 0.1% capacitors be connected into circuit for the purpose of alignment. However, should these components not be readily available the instrument may be aligned without them. The calibration accuracy cannot then be specified as better than ± 4%, although the accuracy is usually within ± 3% when this method is employed.

If the capacitors are to be used, continue with the procedure as at (g). If alignment without the capacitors is required, press in the push-button of the 1KHz - 10KHz range and then continue as at section 3(h).

(g) Disconnect the brown lead from the 'rotor' of SD3 (i.e., a switch on the 10Hz - 100Hz range push-button) and connect it to stator 1 of SD3.

Connect a 0.015μF ± 0.1% capacitor between the copper 'pads' surrounding slots indicated by A and A' in Fig. 4 (Drg. S63/34); connect a second such capacitor between points B and B'.

(h) Measuring the output frequency at the terminals with an electronic counter or oscilloscope, set the dial for an output of 1KHz ± 0.2%.

Without altering the setting of the ganged tuning potentiometers (RV2 and RV4), slacken the two grub screws coupling the slow-motion-drive to the potentiometer's spindle; set the dial to '1' and re-tighten the grub-screws. (Do not damage the screw-threads by over-tightening.)

(i) Adjust the sinewave output control RV7 for an output signal amplitude of 2.5V r.m.s. (frequency 1KHz) with no waveform 'clipping' evident.

(j) Set the dial to indicate '10': adjust RV1 and RV6 in turn by small increments for an output of 10KHz ± 0.2% at 2.5V r.m.s.

(k) Return the dial to '1'.

If the output is not 1KHz ± 0.2% at 2.5V r.m.s., repeat procedures (h) and (i). Subsequently check that the output requirements of procedure (j) are still satisfied; if necessary, re-adjust RV1 and RV6.

(l) Check that the output frequencies at dial settings of 1.1, 3 and 9 are within ± 1.5% of indicated values.

(m) If capacitors have been used for alignment, remove them from the board. Remove the lead previously connected to SD3 stator 1, and re-connect it to SD3 rotor.

(n) Press in the push-button of the 100KHz - 1MHz range. Set the dial to '1' and adjust C16 and C17 in turn by small increments for an output of 101KHz ± 0.2% at 2.5V r.m.s.

This allows for frequency-reduction caused later by the case capacitance.

(o) Set the dial to '10' and adjust RV3 and RV5 in turn by small increments for an output of 1.01MHz ± 0.2% at 2.5V r.m.s.

(p) Return the dial to '1'.

If the output is not 101KHz ± 0.2% at 2.5V r.m.s. repeat procedure (n); then check that the output requirement of (o) is still satisfied: if necessary re-adjust RV3 and RV5.

(q) Press in the 1KHz - 10KHz range push-button (the previous push-button should be released automatically).

(r) Set the dial to '1' and set the Sine/Square-wave switch to 'Squarewave'.

(s) Set the mark/space ratio control RV8 fully-anticlockwise. Observe the output on an oscilloscope.

Set the mark/space ratio to 1 : 1 by slowly turning RV8 clockwise.

(t) Adjust RV9 for an output amplitude of 5V peak-to-peak.

Two positions of control RV8 may yield a 1 : 1 mark-to-space ratio: the position used for the setting should be that nearest to the anti-clockwise end of the track.

4. Fault Finding

Refer to diagram S63/34 at the rear of this manual. Fig. 1 shows the circuit of the TF 2103 and indicates typical waveforms present at various points for correct conditions and for certain fault conditions. The waveforms are numbered for use with the fault finding chart presented as Fig.2.

Figure 3 shows the component side, and Fig. 4 the copper track side, of the printed circuit board.

Proceed as follows -

(i) In Fig. 2 below the heading 'Classified Faults', select the sub-heading corresponding to the nature of the fault (e.g., 'Output on Sinewave Only').

(ii) Proceed down the chart (in the direction of the arrows) carrying out waveform checks according to the instructions in the rectangles; from the rectangles proceed via the side marked '✓' if the waveform is correct, but via the side marked 'X' if the waveform is incorrect.

(iii) When the fault has been localized (i.e., traced to a region shown at the foot of the chart) refer to the manual section as indicated. Typical D.C. conditions which should exist within the circuit are given in Section 4.1.

Notes on Fault Correction

(a) Components should not be removed from the unit unless it is necessary to do so. When removing or inserting a component a heat sink (e.g., pliers) should be used to prevent damage to the component due to heat from the soldering iron.

(b) When removing or inserting components ensure that the supply is 'OFF'; otherwise high voltage surges may damage the transistors.

(c) When heating connections on a printed-circuit board, the board should be in a horizontal plane to prevent solder from flowing across the printed circuit.

(d) If the bias of a transistor is incorrect, check the biasing components: an open circuit 'joint' or a resistor no longer within the required tolerance may be the cause.

(e) Should a transistor be found to be faulty, check the associated components.

(f) After changing component(s) check the calibration and operation of the instrument: if incorrect re-align (See Section 3).

4.1. Typical D.C. Conditions:

All voltages below are given with respect to chassis-earth. Voltages marked 'CRO' are measured on an oscilloscope: other voltages are measured by a suitable multimeter, e.g., 'Universal AVO meter' Model 8; the bracketed figures indicate the D.C. voltage ranges on which the readings were obtained.

'apx' = abbreviation for 'approximately'

Circuit Section	Sine/Square Setting	Transistor	Emitter Voltage	Base Voltage	Collector Voltage
Oscillator	either	VT1(CRO)	-1.6V	-2V	-16.5V
"	"	VT2 "	-H.T.	-16.5V	-8V
"	"	VT3 "	-7.5V	-8V	apx.-H.T.
Inverter	Sinewave	VT4(AVO 8)	-1.7V(10)	-2V(10)	-8.5V(10)
C.E.F.*	"	VT5 "	Apx.-9.5V(10)	-9.7V(10)	apx.-H.T.(25)
"	"	VT6 "	apx.-9.3V(10)	-8.5V(10)	apx.0V(2.5)
"	Squarewave	VT5	apx.-4.2V(10)	-4.5V(10)	apx.-H.T.(25)
"	"	VT6 "	apx.-3.7V(10)	-3.2V(10)	apx.0V(2.5)
Schmitt-trigger	"	VT7 "	apx.-0.35V(2.5)	-0.36V(2.5)	-2V(10)
	"	VT8 "	apx.-0.35V(2.5)	-0.6V(2.5)	-3.2V(10)

D.C. level at junction of MR1 and R1 : apx. -2V(10)

D.C. level at junction of MR4 and R4 : apx. -8.7V(10)

*C.E.F. = Complementary emitter follower

4.2. Localized Fault Tracing

Having traced the fault to a particular region of the circuit, proceed according to the instructions given in the appropriate sub-section below.

The circuit operations are described in Section 5.

4.2.1. Oscillator

(i) Observe the waveforms at VT1 base and emitter, and at the collectors of VT2 and VT3; compare with the waveforms 1, 2 and 3 respectively of Fig. 1 (Drg. S63/34).

(ii) Check the d.c. conditions of the oscillator; refer to Section 4.1.

(iii) Check the thermistor (TH1) and the ganged potentiometers RV2 and RV4.

(iv) Locate and rectify the fault, replacing component(s) where necessary (Components List : Section 6).

Examples of Faults -

Symptom	Possible Cause
1. No oscillation or amplitude of sinewave markedly reduced.	Thermister short-circuited.
2. Clipping of sinewave	Thermistor open-circuited.
3. H.F. oscillations on fundamental sinewave	Capacity of C19 too low (Increase from 10pF to 22pF)
4. Intermittent oscillation	Hair-line crack in copper of printed circuit; or dry joint

4.2.2. Schmitt Trigger

(i) With 'Squarewave' selected, observe the waveforms at the base, emitter and collector of VT7, and at the base and collector of VT8; compare with waveforms 20 to 24.

(ii) Check the d.c. conditions of the Schmitt Trigger stage; refer to Section 4.1.

(iii) Locate and rectify the fault, replacing component(s) where necessary (Components List: Section 6).

Examples of Faults -

Symptom	Possible Cause
Mark/Space ratio incorrect (e.g., waveform 15 Drg. S63/34)	RV8 defective : adjust or replace
Amplitude incorrect (e.g., waveform 14 Drg. S63/34)	RV9 defective : adjust or replace
Top of 'squarewave', at VT8 collector, concave	MR4 operation unstable: check H.T. supply and diode.

4.2.3. Amplifier/Inverter

(i) With Sinewave selected, observe the waveforms at the base, emitter and collector of VT4; compare with waveforms 4 and 5 (Drg. S63/34).

(ii) Check the d.c. conditions of the inverter; refer to Section 4.1.

(iii) Locate and rectify the fault, replacing component(s) where necessary (Components List : Section 6).

Examples of Faults

Symptom	Possible Cause
Excessive distortion	VT4 faulty; high leakage current.
	Incorrect d.c. bias
Amplitude incorrect	RV7 defective; adjust or replace.

4.2.4. Complementary Emitter Follower Output Stage

(i) With Sinewave selected, observe the waveforms at VT5 collector, base and emitter; and at VT6 base, emitter and collector; compare with waveforms 6, 9 and 11 (Drg. S63/34).

(ii) Select Squarewave, observe the waveforms at VT5 base, collector and emitter; and at VT6 emitter and collector; compare with waveforms 7, 8, 10 and 12 (Drg. S63/34).

(iii) Check the d.c. conditions of the complementary emitter follower output stage (refer Section 4.1).

(iv) Locate and rectify the fault, replacing component(s) where necessary (Components List : Section 6).

Examples of Faults

Symptom	Possible Cause
Cross-over distortion (e.g., waveform 19 Drg. S63/34)	VT5 and VT6 gains mismatched
	Incorrect d.c. bias C20 and/or R34 values out of tolerance
Sinewave peak-distortion (e.g., waveform 18 Drg. S63/34)	VT5 or VT6 low gain

4.2.5. Attenuator

(i) If the output level is correct for the '1V' setting of the Output switch SA2 (the amplitude being dependent on the setting of RV10), but is incorrect on one or more of the remaining positions of the switch, check the attenuator components and connections.

(ii) Locate the fault, replacing component(s) as necessary (Components List : Section 6).

Examples of Faults

Symptom	Possible Cause
Overshoot on squarewave output (e.g., waveform 16 Drg. S63/34)	C14 or C15 defective
Output amplitude (sine or square wave) incorrect for one or more positions of the output switch	Defective attenuator resistors; check circuit and values.

5. Circuit Description

The circuit is treated in four sections as follows -

Oscillator
Inverter Amplifier
Schmitt Trigger (pulse squarer)
Output Stage

5.1. Oscillator

The signal source is a Wien-bridge variable frequency oscillator; transistors VT1 and VT2 are connected to form a feedback pair and VT3 as an emitter follower oscillator-output stage. Gain of the VT1-VT2 combination is set by R10 and R11.

The fine frequency control comprises the semi-precision ganged potentiometers RV2 and RV4 which vary the resistive bridge-elements.

Range selecting is effected by switching into circuit highly stable capacitors. On ranges 1 to 4 (10Hz - 100KHz) the series limb of the Wien-bridge network comprises capacitor C9, 10, 11 or 12 (as selected by push-button SD, SE, SF or SG), RV6, RV4 and R9, whilst the shunt limb comprises capacitor C4, 5, 6 or 7 (as selected by push-button SD, SE, SF or SG), RV2, RV1 and R8. A capacitor C23 in series with C7 is used to compensate for the effect of stray capacity. Resistors R32 and R33 are included only when compensation for variations in the normal resistance laws of RV2 and RV4 is necessary. The settings of RV1 and RV6 determine the accuracy of calibration at the upper frequency end of the ranges.

On range 5 (100KHz - 1MHz) the frequency-determining capacitors are C8 trimmed by C16 (shunt-limb) and C13 trimmed by C17 (series-limb); the capacitors are selected by push-button SH. The trimmers C16 and C17 enable allowance to be made for circuit stray capacity. For this range RV3 is switched in parallel with RV1, and RV5 in parallel with RV6.

The bias supply for VT1 base is provided by the potential divider

R1-MR(1-3) connected across the H.T. supply.

5.2. Inverter Amplifier

This stage, used only on sinewave operation to pass oscillator signals to the output stage, comprises VT4 which is biased by means of R5 and R15. Potentiometer RV7 serves as a preset sinewave amplitude control. Negative feedback is introduced since R16 is not by-passed.

5.3. Schmitt Trigger

The Schmitt Trigger circuit, or squarer, consists of the switching-transistors VT7 and VT8. Output signals of rectangular waveform are produced at the collector of VT8 when sinusoidal oscillator-output signals are applied to the base of VT7.

The silicon diode MR4 functions as a voltage regulator; it controls the d.c. voltage applied to the base and collector circuits of VT7 and ensures that the squarewave amplitude is held constant for variations of supply voltage.

The potentiometer RV8 serves as a preset trigger level (or mark/space ratio) control: RV9 controls the collector voltage of VT8 and with MR5 functions as a preset amplitude control for the squarewave output.

Supplied by the collector output of VT7, resistors R22 and R24 serve as a potential divider for the base of VT8.

Use of this type of circuit ensures that fast rise and fall times are obtained for the output pulse; the times being independent of signal frequency.

5.4. Output Stage

This stage comprises transistors VT5 (p-n-p) and VT6 (n-p-n) connected in a complementary emitter follower configuration which provides an output impedance of approximately 100Ω and maintains the fast rise and fall times of the waveform presented by the Schmitt Trigger circuit on squarewave operation.

The transistors are biased by means of R6, MR6 and MR7.

In the output circuit C3 functions as a blocking capacitor.

The switched attenuator, comprising R25-30 and the frequency compensating capacitors C14 and 15, is connected to the slider of the variable output control RV10 and provides attenuation factors of 20, 40 and 60dB. The attenuator is arranged to have an output impedance of 600Ω.

6. Spares Ordering Information

When ordering spare parts quote both the equipment type number and

the FPP part number, e.g., TF 2103 FPP/X12345/67.

Components may be ordered via Marconi Instruments Distributors, or direct from -

Service Division,
Hedley Road,
St. Albans,
Hertfordshire,
England.

Marconi Wide Band Oscillator type TF 2103

Components List (References as per circuit ES66/10, Issue D)

Resistors:

	Value	Tolerance	Rating	Marconi Part No.
R1	3.9KΩ	± 10%	$\frac{1}{4}$W	TF 2103FPP/X20635/11/P
R2,21,23	3.3KΩ	"	"	" " /10/P
R3	100Ω	"	"	" " /44/P
R4	680Ω	"	"	" " /4/P
R5	10KΩ	± 2%	"	" /X20636/14
R6	4.3KΩ	"	"	" " /83
R7,17,19,37	47Ω	± 10%	"	" /X20635/34/P
R8	180Ω	"	"	" " /51/P
R9	470Ω	"	"	" " /3/P
R10	1.5KΩ	"	"	" " /7/P
R11	8.2KΩ	"	"	" " /15/P
R12	220Ω	"	"	" " /1/P
R13,31	150Ω	"	"	" " /46/P
R14	1KΩ	"	"	" " /6/P
R15	1.3KΩ	± 2%	"	" /X20636/74
R16	1KΩ	"	"	" " /66
R18	68Ω	± 10%	"	" /X20635/48/P
R20	47KΩ	"	"	" " /23/p
R22	1.8KΩ	"	"	" " /8/P
R24	10KΩ	"	"	" " /16/P
R25,27	680Ω	± 2%	$\frac{1}{4}$W H.S.	" /X20636/16
R26	620Ω	"	" H.S.	" " /71
R28,29,30	5.6KΩ	"	" H.S.	" " /67
R32,33	470KΩ	± 10%	"	" /X20635/32

Resistors Variable:

	Value		Marconi Part No.
RV1,3,5,6	1KΩ	Plessey	TF 2103FPP/X20999/31
RV2/4*	10KΩ (per section)	Colvern	" " /29
RV7	2.2KΩ	Plessey	" " /36
RV8	68KΩ	Plessey	" " /34
RV9	6.8KΩ	Plessey	" " /32
RV10	1KΩ	Colvern	" " /30

* Ganged

Capacitors:

	Value	Tolerance	Rating	Marconi Part No.
C1	2000µF	-20% +50%	12V	TF 2103FPP/Y20643/27
C2,18	200µF	-20% +100%	25V	" " /22
C3	500µF	" "	"	" " /28
C4,9	1.5µF Ø	± 1%	125V	" /Y23914/22
C5,10	0.15µF	"	"	" " /21
C6, 11	0.015µF	"	"	" " /20
C7,12	1500pF	"	"	" /Y23914/19
C8	60pF	± 10%	"	" /Y20641/9
C13	150pF	"	"	" " /12
C14	22pF	"	"	" " /16
C15	270pF	"	"	" " /19
C16,17	4-60pF	(trimmers)	-	" /Z21135/5
C19,20	33pF	± 10%	125V	" /Y20641/14
C21	2000pF	"	"	" " /21
C22	0.1µF	± 20%	150V	" /Y20642/4
C23	0.04µF	"	"	" " /3
C24 ⊄	47pF	± 10%	125V	" /Y20641/15

Ø Value formed by two parallel-connected capacitors

⊄ Note: Some models fitted with C24; between VT8 collector and chassis-earth (copper side).

Diodes:

	Type		Marconi Part No.
MR1,2,3,5	OA91	Mullard	TF 2103FPP/X20639/12/P
MR4	OAZ272	Mullard	" " /28/P
MR6,7	IS 920	Mullard	" " /18/P

Transistors:

	Type		Marconi Part No.
VT1,3,4,5	AF124	Mullard	TF 2103FPP/Z20638/58
VT2,6	2N706	S.T.C.	" /Z20638/52
VT7,7	2N711	Texas	" /Z20638/38

Thermistor:

	Type		Marconi Part No.
TH1	R23	S.T.C.	TF 2103FPP/Y23955/3

Indicator Lamp:

	Type	Rating	Marconi Part No.
ILP 1	Vitality Tubular LES 679	12V 1W	TF 2103FPP/Z22749

Terminals:

	Type	Marconi Part No.
TP1	Black	TF 2103FPP/Z26796/1
TP2	Red	" /Z26797/1

Switches:

	Type	Marconi Part No.
SA (1-2)	2p. 5" (rotary)	TF 2103FPP/625/2/1
SB (1-3)+SC(1-3)	2x3p.2W (push-button)	" /625/4/1
SD (1-3)to SH(1-3)	5x3p.2W (push-button)	" /625/3/1
SJ	Open push-button	" /Z26855

Battery (2 required)

Type	Rating	Marconi Part No.
Vidor VT9 or Ever Ready PP9	9V	TF 2103FPP/Y50084

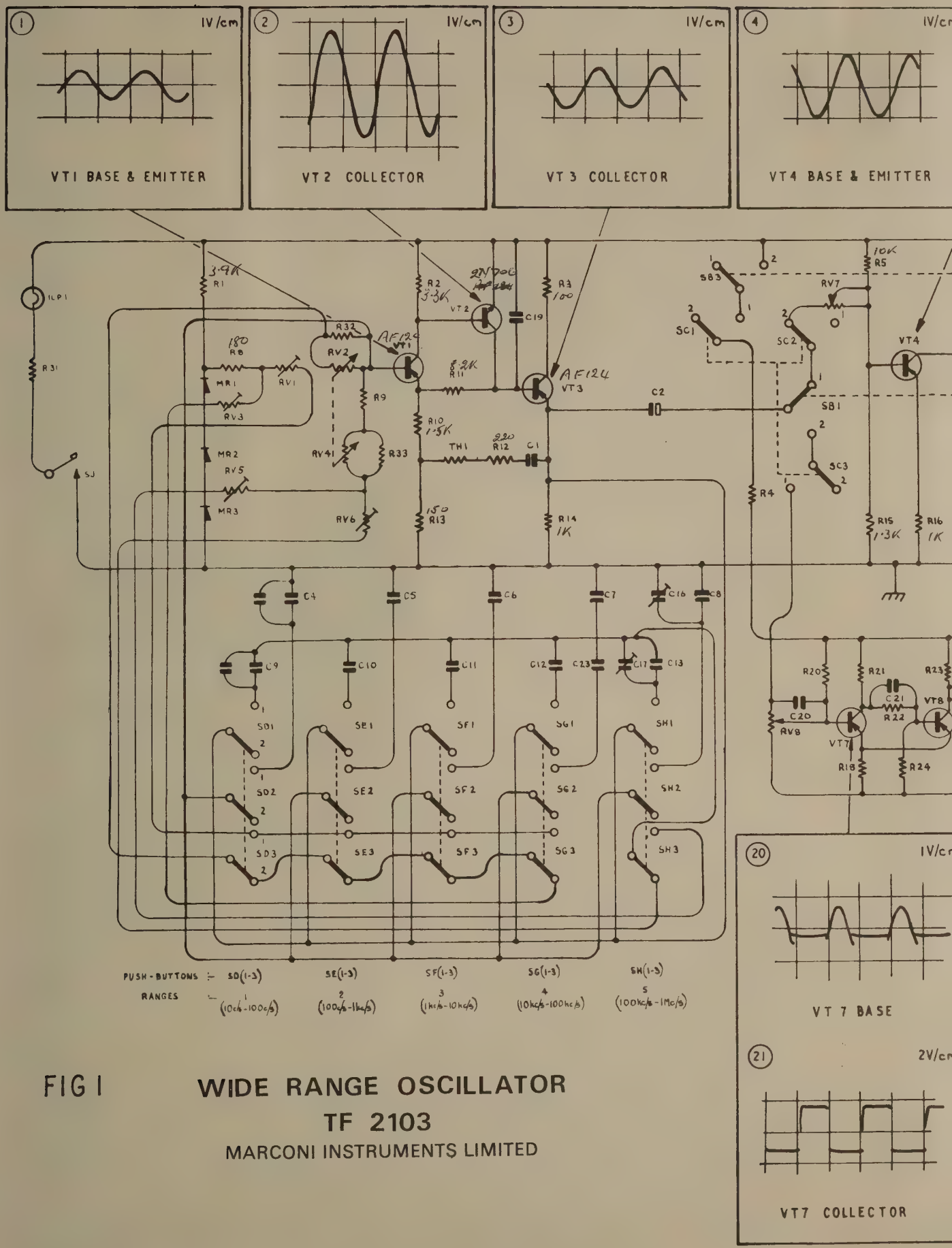
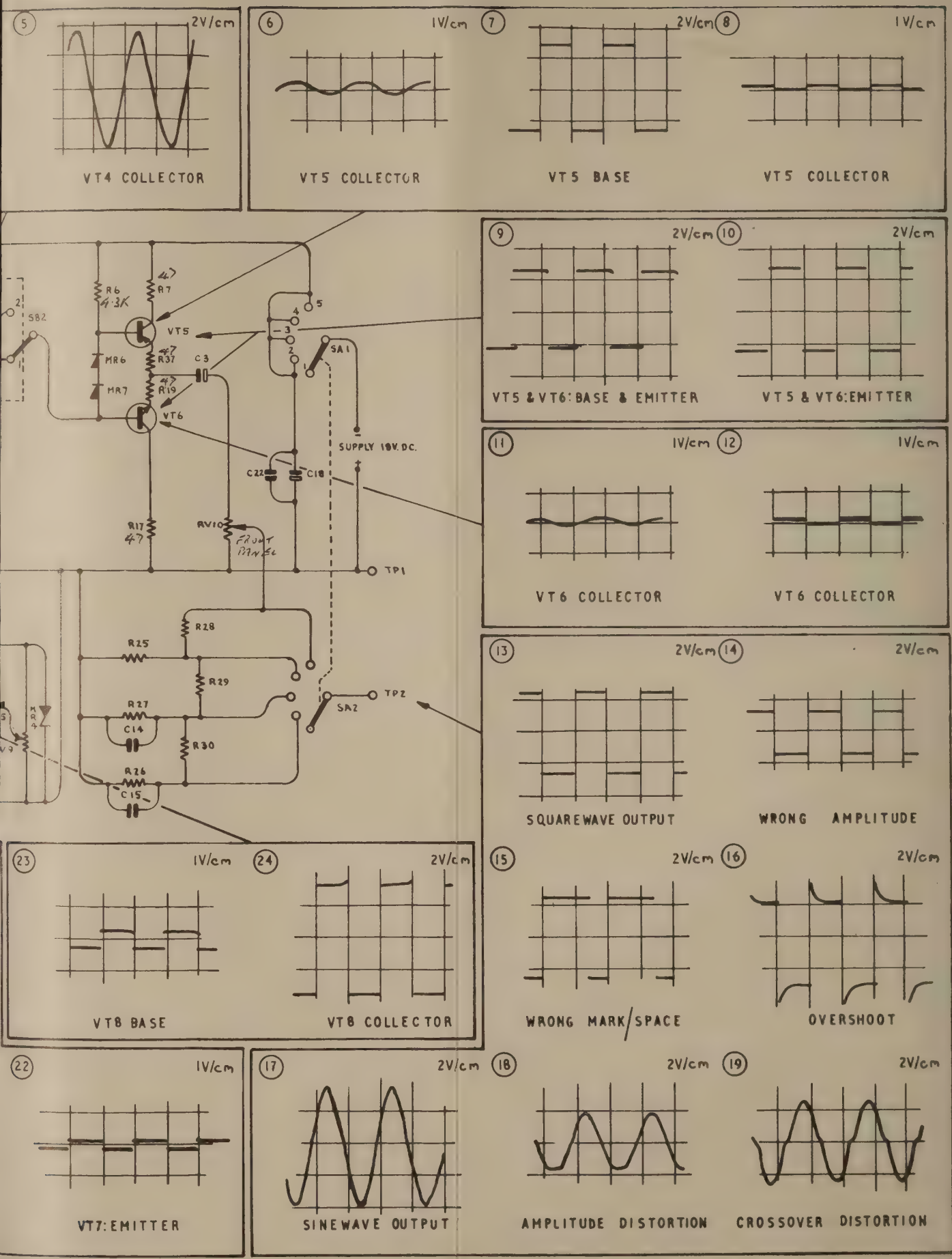
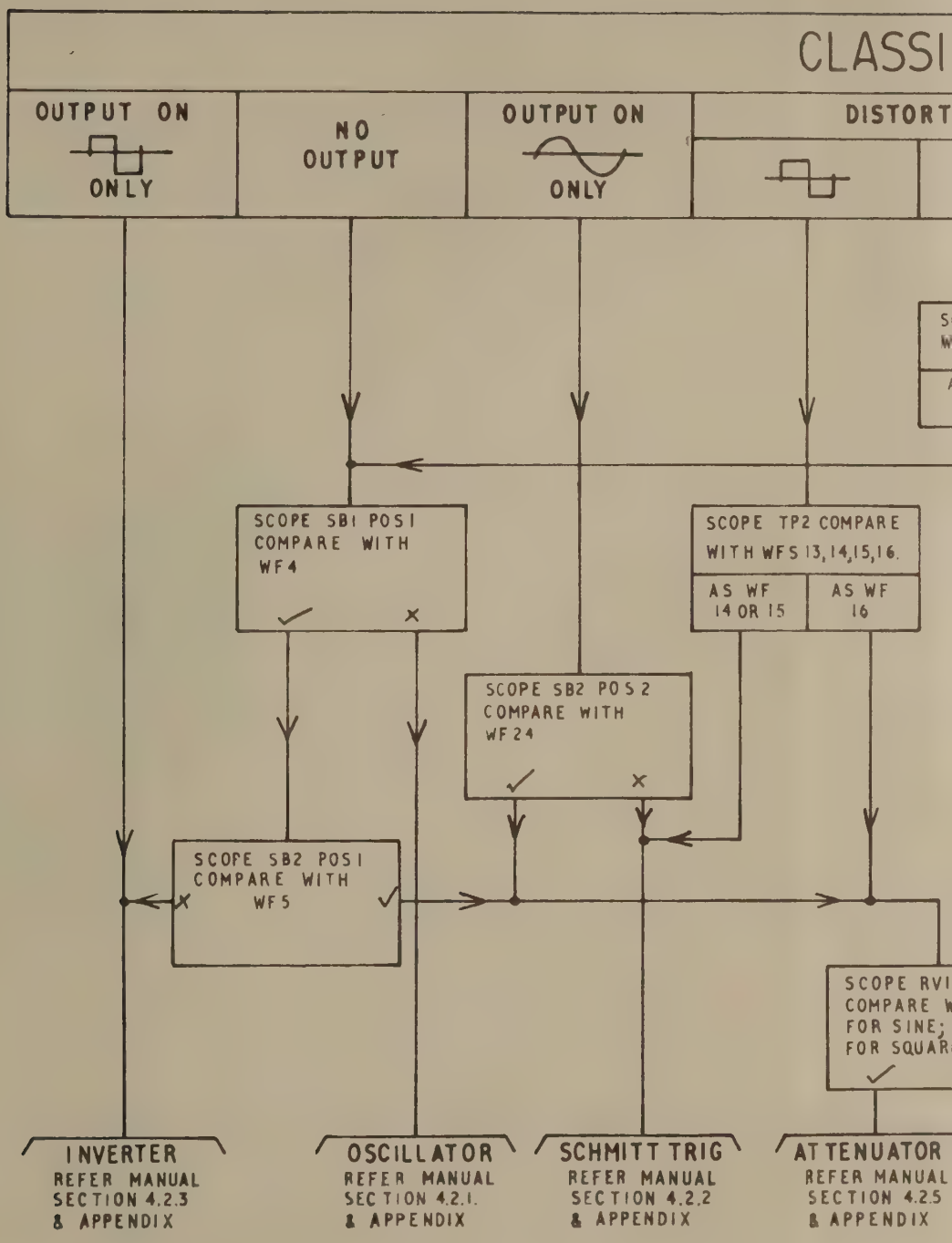


FIG 1

WIDE RANGE OSCILLATOR
TF 2103
MARCONI INSTRUMENTS LIMITED


5
2V/cm
VT4 COLLECTOR
6
1V/cm
VT5 COLLECTOR
7
2V/cm
VT5 BASE
8
1V/cm
VT5 COLLECTOR
9
2V/cm
VT5 & VT6: BASE & EMITTER
10
2V/cm
VT5 & VT6: EMITTER
11
1V/cm
VT6 COLLECTOR
12
1V/cm
VT6 COLLECTOR
13
2V/cm
SQUAREWAVE OUTPUT
14
2V/cm
WRONG AMPLITUDE
15
2V/cm
WRONG MARK/SPACE
16
2V/cm
OVERSHOOT
17
2V/cm
SINEWAVE OUTPUT
18
2V/cm
AMPLITUDE DISTORTION
19
2V/cm
CROSSOVER DISTORTION
22
1V/cm
VT7: EMITTER
23
1V/cm
VT8 BASE
24
2V/cm
VT8 COLLECTOR
R6 4.3K
R7
SB2
VT5
MR6
MR7
R37
R19
C3
VT6
SA1
SUPPLY 18V. DC.
C22
C18
R17 47
RV10
FRONT PANEL
TP1
R28
R25
R29
R27
C14
R30
R26
C15
SA2
TP2


CLASSI
OUTPUT ON
ONLY
NO
OUTPUT
OUTPUT ON
ONLY
DISTORT
SCOPE SB1 POS1
COMPARE WITH
WF4
SCOPE TP2 COMPARE
WITH WFS 13,14,15,16.
AS WF
14 OR 15
AS WF
16
SCOPE SB2 POS 2
COMPARE WITH
WF 24
SCOPE SB2 POS1
COMPARE WITH
WF5
SCOPE RVI
COMPARE W
FOR SINE;
FOR SQUAR
INVERTER
REFER MANUAL
SECTION 4.2.3
& APPENDIX
OSCILLATOR
REFER MANUAL
SECTION 4.2.1.
& APPENDIX
SCHMITT TRIG
REFER MANUAL
SECTION 4.2.2
& APPENDIX
ATTENUATOR
REFER MANUAL
SECTION 4.2.5
& APPENDIX

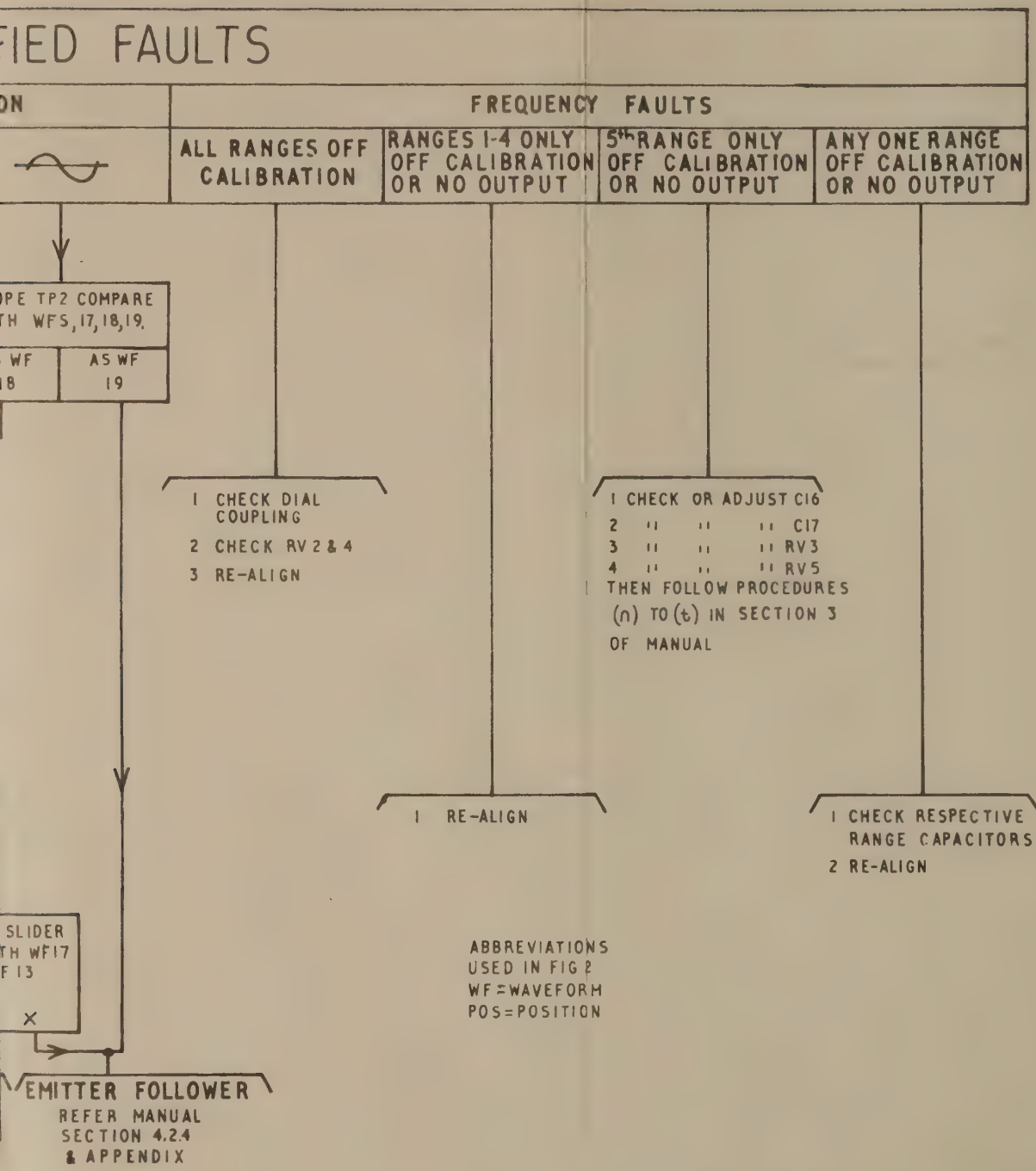

FIED FAULTS
ON
FREQUENCY FAULTS
ALL RANGES OFF CALIBRATION
RANGES 1-4 ONLY OFF CALIBRATION OR NO OUTPUT
5th RANGE ONLY OFF CALIBRATION OR NO OUTPUT
ANY ONE RANGE OFF CALIBRATION OR NO OUTPUT
PE TP2 COMPARE TH WFS, 17, 18, 19.
WF 18
AS WF 19
1 CHECK DIAL COUPLING
2 CHECK RV2 & 4
3 RE-ALIGN
1 CHECK OR ADJUST C16
2 " " " C17
3 " " " RV3
4 " " " RV5
THEN FOLLOW PROCEDURES (n) TO (t) IN SECTION 3 OF MANUAL
1 RE-ALIGN
1 CHECK RESPECTIVE RANGE CAPACITORS
2 RE-ALIGN
SLIDER TH WF17 F 13
X
EMITTER FOLLOWER
REFER MANUAL SECTION 4.2.4 & APPENDIX
ABBREVIATIONS USED IN FIG 2
WF = WAVEFORM
POS = POSITION

FIG 2

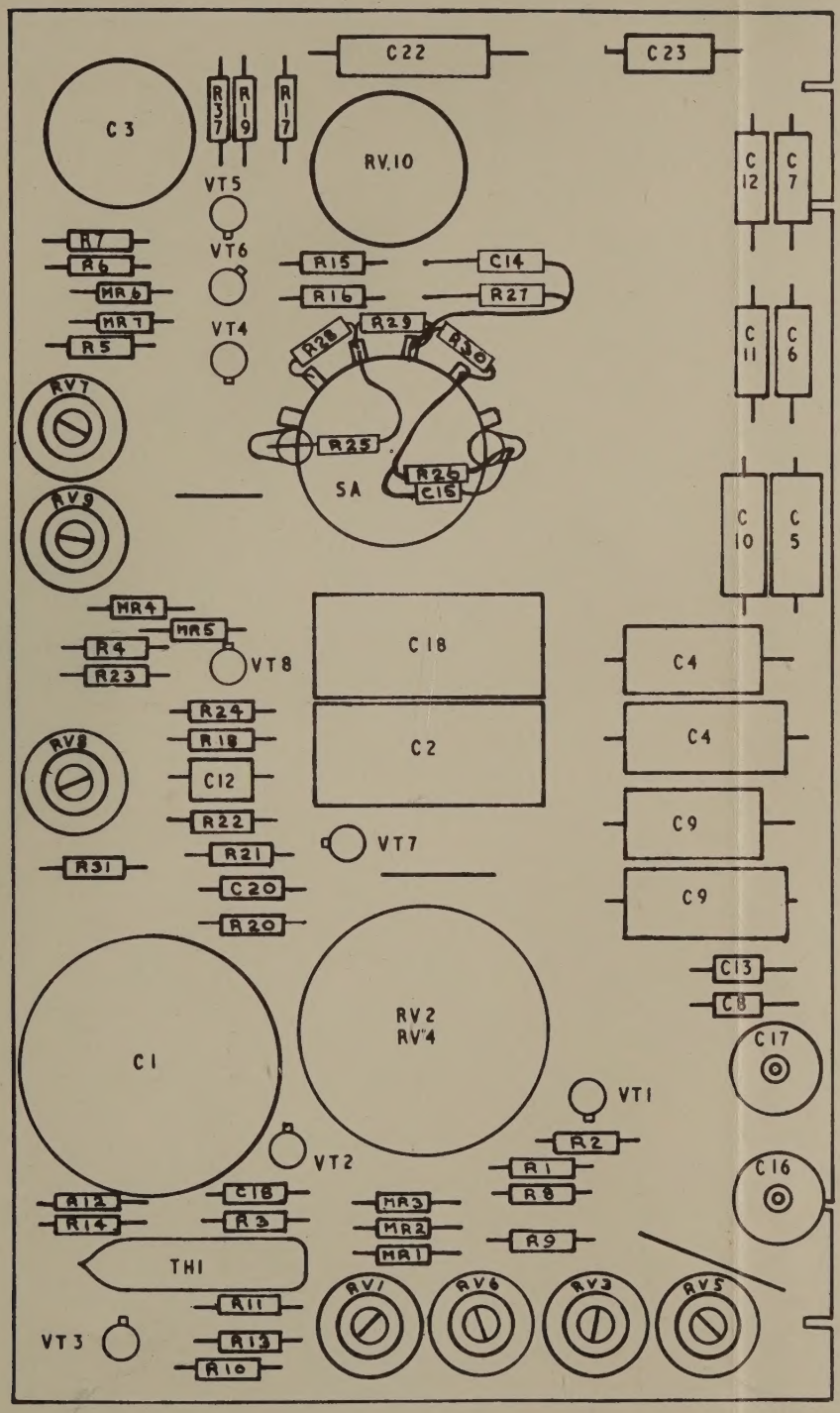

C22
C23
C3
R37
R19
R17
RV.10
C12
C7
VT5
VT6
VT4
R7
R6
MR6
MR7
R5
R15
R16
C14
R27
R29
R28
R30
C11
C6
RV7
RV9
R25
R26
C15
SA
C10
C5
MR4
MR5
R4
R23
VT8
C18
C2
C4
C4
R24
R18
C12
R22
R21
C20
R20
RV8
R31
VT7
C9
C9
C13
C8
C17
RV2
RV4
C1
VT1
VT2
R2
R1
R8
C16
R12
R14
C18
R3
MR3
MR2
MR1
R9
TH1
RV1
RV6
RV3
RV5
R11
R13
R10
VT3

FIG 3

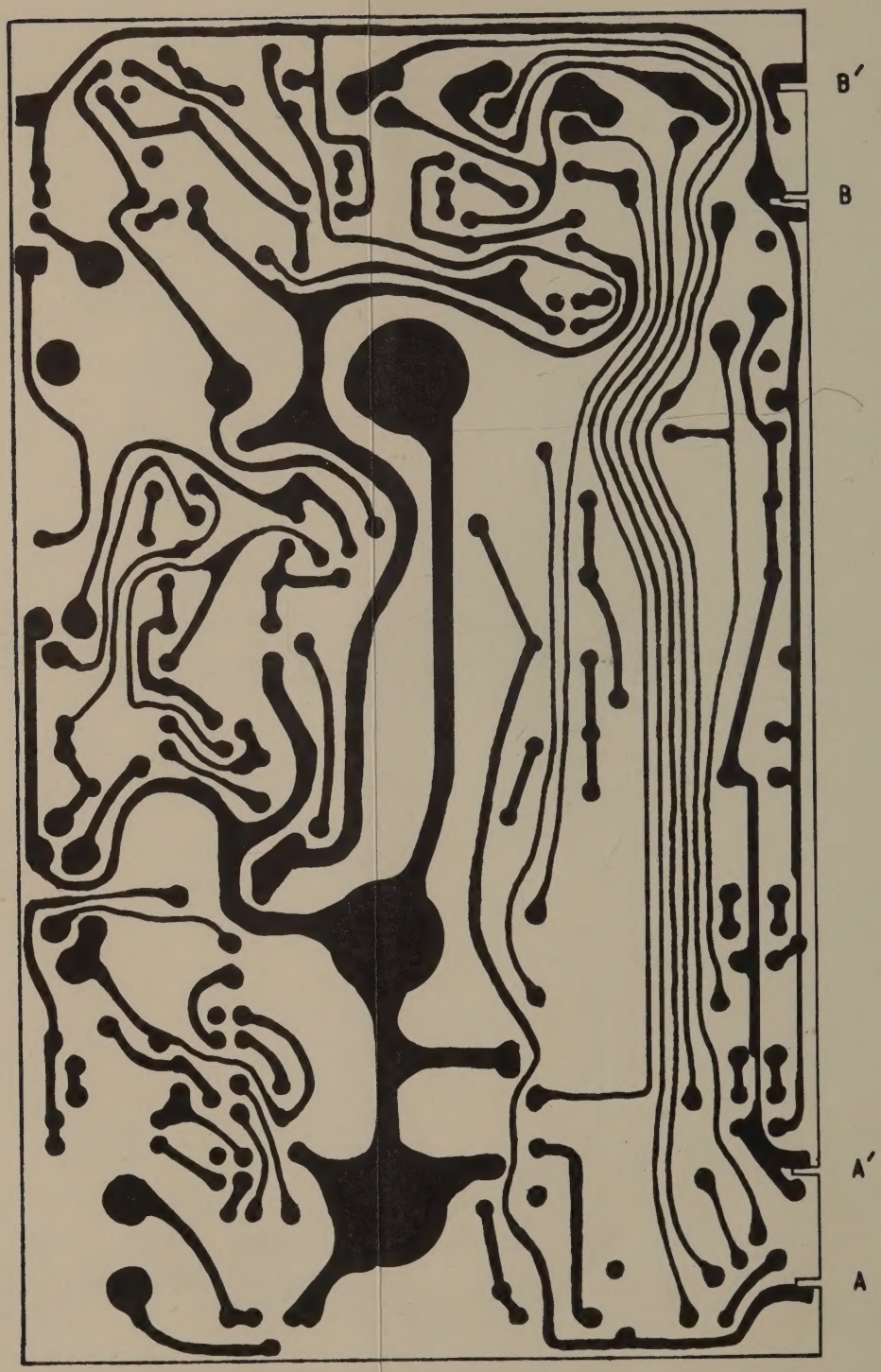


FIG 4

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